MATHEMATICAL STUDIES TZ1

Overall grade boundaries

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 17	18 - 33	34 - 42	43 - 54	55 - 66	67 - 77	78 - 100

Time zone variants of examination papers

To protect the integrity of the examinations, increasing use is being made of time zone variants of examination papers. By using variants of the same examination paper candidates in one part of the world will not always be taking the same examination paper as candidates in other parts of the world. A rigorous process is applied to ensure that the papers are comparable in terms of difficulty and syllabus coverage, and measures are taken to guarantee that the same grading standards are applied to candidates' scripts for the different versions of the examination papers. For the May 2014 examination session the IB has produced time zone variants of Mathematical Studies papers.

Standard level Project

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 4	5 - 6	7 - 8	9 - 11	12 - 14	15 - 16	17 - 20

The range and suitability of the work submitted

There was a wide range of marks as usual. Most of the topics were statistical and were suitable for a Mathematical Studies SL project but there are always a few that should have been actively discouraged by the teachers to start with. Some candidates had obviously worked hard on their project and enjoyed the process and this was obvious from the care that was taken to satisfy all the assessment criteria and, as a result, these candidates scored highly on all the criteria. However, there were others that showed little, if any, commitment and produced a trivial or incomplete piece of work. Some schools did not realize that the projects had to include two simple processes first before a further process was attempted and these scored poorly on Criterion C. Many candidates lost a mark due to improper notation and/or terminology or failing to define variables and teachers should take more care to point this out to their students. Some teachers were still using the old criteria and the 5/PJCS for the previous syllabus. Such work was moderated against the correct May 2014 criteria. Teachers should refer to the current guide and the up-to-date handbook of procedures (where the 5/PJCS is saved). It is important that teachers write detailed comments on the front of the cover sheet explaining why the marks were awarded. They are also encouraged to make comments throughout the project in pencil in the margins and check the accuracy of the mathematics.

Candidate performance against each criterion

Criterion A:

Many candidates were awarded a level 2 out of a possible 3. This was mainly due to the fact that they did not give any reasons for the processes they were going to use.

Some candidates only scored 1 mark because their plan was not clear or their project had no title.

To award level 3 there should be no surprises when reading the project. For the plan to be considered detailed, the student should describe precisely all the mathematical processes to be used and the reasons for choosing each of these processes.

If any processes are used that are not discussed in the introduction then at most level 2 can be awarded.

If any process is explained in the introduction but not performed, then at most level 2 can be awarded.

Candidates with a clear statement of task and detailed plan discussing the processes to be used and the rationale behind their choices usually produced excellent projects.

Criterion B:

Most candidates collected data that was appropriate for their project but it was not always sufficient in quantity to perform the processes set out in their plan.

Few candidates described their sampling process clearly and so were not awarded full marks for this criterion.

The collection process must be thoroughly described and must be representative of the population. Saying that the data was randomly collected is insufficient. The sampling process must be explained. If sampling is not done then this must be justified.

If no real organization of the data is required then at most level 2 can be awarded for this criterion.

Raw data must be seen to consider level 2 for this criterion.

Calculations must be able to be checked.

Data that is too simple also limits the marks for other criteria such as the mathematical processes, interpretation and communication.

Criterion C:

Most of the changes in the new assessment criteria are in this criterion. Not all teachers and candidates paid attention to the changes and, as a result, did not score well.

The candidates must complete at least two simple processes that are correct and relevant to be awarded level 3 for this criterion. It is required that only all *simple* processes are relevant at this level. Irrelevant further processes do not preclude the candidate being awarded level 3.

Simple processes are considered relevant if they pertain to the statement of task and if these processes are used later in the development of further processes, as stated in their plan.

If there are no simple processes in the project, then two of the further processes will be considered to be simple processes and **not** further processes.

Repeated processes count as one process (e.g. producing two bar charts).

If the project includes only two processes and one is incorrect, then level 1 is the maximum which can be awarded.

If there is only one process used, simple or further, then the candidate is awarded level zero.

If the simple and further processes are not presented in order, the student will not be penalized in this criterion. However this may be penalized in criterion F.

To be awarded level 5 all further processes (and there only needs to be one) must be without error, and must be relevant.

Any process that is beyond the course needs to be fully explained to be considered a further process, for example the unsupported use of the *t*-test, whether performed wholly on the GDC or by substitution into the formula is deemed a simple process.

Although the processes are not limited to the chi-squared test and calculating the regression equation, the frequency with which they appear makes it worthwhile producing further guidance on how they should be marked.

Chi-squared test

A χ^2 test performed by hand is considered to be one further process.

For a completed χ^2 test candidates are expected to write down their hypotheses, degrees of freedom, show how to calculate at least one expected value and complete the table of expected values, work out the chi-squared test statistic using the formula and write down the conclusion (using either the critical value or the significance level).

If the observed values are not frequencies, then at most level 3 can be awarded for criterion C.

If any expected values are less than 5, then at most level 4 can be awarded for criterion C, and only if all the working is shown in full. If the working is not shown, then at most level 3 can be awarded.

If the degree of freedom is 1, then Yates continuity correction must be applied (and only when the degree of freedom is 1). If the correction factor is not applied and the test has been satisfactorily performed by hand then at most level 4 can be awarded.

Candidates should note that a χ^2 test does not prove anything. It supplies evidence or support only.

Correlation / regression

If the candidate draws a scatter diagram and it is clear from the diagram that there is no correlation then it is relevant to calculate the correlation coefficient, r , to verify that fact. However, it is not relevant to calculate the regression line.

If from the scatter diagram it seems that there is some correlation then it is relevant to calculate the correlation coefficient, r , and, if the correlation is strong enough, then it is relevant to find the regression line, provided it is used or its purpose explained.

If a scatter graph is not drawn, then the relevancy of a regression line will depend on the value of r .

If the value of r is written down from the GDC (or Excel) then this is a simple process.

If the summary statistics have been calculated from the GDC and then substituted into a formula to determine r this is also a simple process.

Calculation of the mean or standard deviation as part of calculating r is not considered a separate process. The exception to this is if the mean or standard deviation has been calculated independently as part of the stated plan.

Normal distribution

Sketching a normal distribution curve and calculating probabilities or percentages is a simple process.

Using z-scores is also a simple process.

If a χ^2 goodness of fit test is performed by hand, then this is a further process.

Criterion D:

The project flows better if the candidate writes partial interpretations/conclusions after each mathematical process.

Most candidates managed to give at least one interpretation that was consistent with their analysis. However, the wording in this criterion has now changed and, if there are any inconsistent conclusions/interpretations, then there must be at least two consistent conclusions/interpretations for the candidate to be awarded level 2.

Any irrelevant or unsupported conclusions (or personal beliefs) preclude the award of level 3.

Criterion E:

Many candidates now show more understanding of validity and are able to comment meaningfully on the mathematical processes used or recognize limitations and provide a discussion.

Recognizing and commenting on the need to use the Yates' continuity correction factor or combining groups in the χ^2 test is sufficient for this criterion.

Criterion F:

Overall the structure of the projects was good. However, this criterion covers more than the layout, it also deals with commitment. The project must demonstrate the required time commitment otherwise the maximum that can be awarded is level 1.

Some candidates included unsupported generalizations and this does not lead to a coherent project. Also, a large number of repetitive procedures preclude the award of level 3.

Graphs, tables or processes presented out of order also preclude the award of level 3.

If many pages of raw data or calculations via spreadsheet are presented, it is preferred that these be shown in an appendix; however this is not penalized.

If processes have been mentioned in the introduction and have not been performed or vice versa then the candidate is not penalized twice for the same error.

Criterion G:

Surprisingly few candidates scored full marks on this criterion. The most common level awarded was 1 due to incorrect notation and/or terminology or failure to define variables.

Candidates that use Excel or calculator screen dumps need to be aware that this notation is not acceptable. If there are examples of such notation this must be explained and corrected in the body of the text.

Candidates should avoid using their cameras to take pictures of calculator screens.

Isolated typographical errors are condoned, however if the candidate uses $x \wedge 2$ instead of x^2, for example, this is poor notation and the maximum that can be awarded is level 1.

Examples of notation:

Correct notation	**Incorrect notation**
x^2	$x \wedge 2$ **or** $x2$
$x \times 2$ **or** $2x$	$x * 2$
1.2×10^{-3}	1.2 E-03
χ^2	X^2 **or** x^2
r^2:Coefficient of determination	r^2:Correlation coefficient
$\sqrt{\frac{2402}{16}}$ **or** $\sqrt{\ }(2402/16)$	$\sqrt{\ }$ 2402/16 **or** sqrt.

Recommendations and guidance for the teaching of future candidates

- Read the Subject Report. This is extra important with the new set of criteria.
- Set internal deadlines for the project.
- Have students assess previous projects to gain an understanding of the assessment criteria.
- Encourage students to show calculations by hand even if they are making use of technology such as Excel.
- Help the students to understand how to address validity.
- Encourage the students to use at least two simple processes in their analysis.
- Make sure that the students define any variables in their project.
- Show the students how to use equation editor and where to find the symbol for χ.
- Show the students how to use Yates' continuity correction.
- Make sure that students attach all raw data.
- Explain sampling to the students.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 13	14 - 27	28 - 34	35 - 46	47 - 57	58 - 69	70 - 90

The areas of the programme and examination which appeared difficult for the candidates

- Rounding to given decimal places and significant figures.
- Determining if two lines are perpendicular to each other.
- Finding the equation of the normal at a given point and expressing this in the form ax + by + d = 0 , where a , b and d are integers.
- Working with exponential models.
- Finding the equation of a horizontal asymptote of a graph.
- Compound interest (non-yearly).
- Working with quadratic functions.
- Complex logic problems.

The areas of the programme and examination in which candidates appeared well prepared

- Measures of central tendency and dispersion,
- Truth tables and simple logic,
- χ^2 test,
- Currency conversion.
- Probability tree diagrams.
- Using trig functions to find the sides of right-angled triangles.
- Finding the volume of three dimensional solid figures.
- Finding the slope and midpoint of a line.
- Simple differentiation.

The strengths and weaknesses of the candidates in the treatment of individual questions

Question 1: decimal places, significant figures and standard form

Despite a significant number of candidates scoring well on this question, many candidates failed to use their calculator correctly. Common errors identified were: the use of radians; dividing by $\sqrt{8192-64}$; or evaluating $\frac{2\cos 45 - \tan 45}{\sqrt{8192}} - 64$. Such candidates earned, at most, method in part (a).

For a minority of candidates there seemed to be some confusion with the phrase ‘write down your full calculator display’ and either wrote down the substituted formula or a rounded answer. Despite errors in part (a), part (b)(i) tended to be a correct follow through answer but, surprisingly, part (b)(ii) was often incorrectly written as 0.0156. Clearly such candidates incorrectly counted the first 0 after the decimal point as a significant figure. In part (b)(iii) many candidates rounded their answer to part (a) for their mantissa and therefore lost this mark. The exponent tended to be correct.

Question 2: descriptive statistics: measures of central tendency and dispersion

Generally well done although some candidates seemed to be confused between the three measures of central tendency in parts (a) and (b) and it was not unusual to see an incorrect answer of 4.38 appearing as an answer here. A significant number of candidates had difficulty with parts (c) and (d) because they did not seem to realize that upper and lower quartile referred to Q_3 and Q_1.

Question 3: logic: truth tables and translation of compound propositions

Although this question was done well by the majority of candidates, there were still a significant number of candidates who, despite standard truth tables being given in the formula booklet, made errors in table entries in part (b). Candidates seemed to be well drilled in the use of *if…then…* and many correct textual interpretations were seen in part (a).

Question 4: χ^2 test for independence.

In part (a), the majority of candidates seemed to be well drilled in using the word *independence* in a Null Hypothesis. A minority of candidates, however, seemed to be confused as to what was independent and some scripts identified, incorrectly, that gender was independent from the university studies. Many correct values were seen in parts (b) and (c) although some candidates lost a mark in part (c)(ii) as they simply gave their answer as 0.01. Candidates should be advised to give all figures from their calculator display as even two significant figures (which *were* awarded the mark here) made it difficult to compare the *p*-value with the given significance level in part (d). Indeed, although there were a significant number of candidates who correctly drew conclusions in part (d), some candidates seemed to be confused between χ^2 and the *p*-value and tried to compare these.

Question 5: currency conversion and commission

Many candidates lost at least one mark on this question for either giving too many figures after the decimal point or for truncating rather than rounding. An example of this was prevalent in part (a) where the calculation of $6600 \times \frac{1}{8.2421}$ resulted in the figures 800.766795. This was frequently either left as this or truncated to 800.76. In both cases, method was earned but accuracy was lost. In part (b), the correct answer of \$84 was frequently seen but, on a significant number of scripts this was then converted to 109.12 SGD thus losing at least one mark. In part (c), 3897.09 proved to be a popular but erroneous answer as many candidates simply multiplied 3000 by the exchange rate but ignored the commission. Despite these issues, this question was generally well answered.

Question 6: cumulative frequency and statistical measures

Parts (a) and (b) were generally well done although some candidates, who had an incorrect table in part (b) should have been in a position to check their data from the information given in the question. Summing the frequencies and getting a total other than 80 should have been enough of a prompt for re-checking the table. The most common error given for part (c) was the frequency value rather than the mid-class value. A significant number of candidates were fortunate in their responses to part (d)(i). Giving an answer of 68 (67.5 correct to 2 significant figures) was awarded the A2 mark here. However, 68 is also the mean of the figures 25, 60, 75, 85 and 95. As the working was done on the calculator, there was no *incorrect* working seen so the marks were awarded.

Question 7: probability

The tree diagram in part (a) was successfully completed by the majority of candidates and many went on to arrive at the required probability in part (b). Some weaker candidates, however, either focused on one branch of their tree diagram or seemed to be confused between when to add and when to multiply with this part of the question and, as a consequence, earned no marks for part (b).

Question 8: trigonometry and geometry of three-dimensional solids

Despite some candidates either working in radians or incorrectly finding the length of the slope of the cone, part (a) was generally well done. Many candidates wrote down a correctly substituted formula for the volume of a cone (with their height substituted) but then a significant number stopped or simply added the volume of a sphere (rather than a hemisphere). A significant minority did everything correct but failed to give the correct units and, as a consequence, the last mark was lost. Despite such errors, there were many full mark responses to this question.

Question 9: midpoints, gradients and perpendiculars

Parts (a) and (b) were generally well done but part (c) was very problematic to the majority of candidates. Indeed, very few knew how to progress with this part of the question and only a minority realized that they needed to find the gradient of OM and then show that the product of this gradient and their answer to part (b) is -1. More candidates tried to use Pythagoras but, in many cases, they were not always working with the correct triangle. Some fully correct solutions were seen but these were from a distinct minority of candidates.

Question 10: calculus, gradients and equation of a normal

Part (a) was invariably answered correctly and, for confident candidates, part (b) was also done well. Some candidates however tried to find the gradient of the tangent by the gradient formula. Indeed, 65 was a common, but erroneous, answer which was generated by finding the gradient between the two points $(2, 16)$ and $(3, 81)$. Irrespective of a correct or incorrect answer to part (b), many candidates could not write down the gradient of the normal in part (c) with many simply writing down a correct equation of a straight line but using their answer to part (b) as the gradient. *Giving your answer in the form ax + by + d = 0 , where a , b and d are integers* proved too much for the majority of candidates as very few final equations were in the correct form.

Question 11: mathematical modelling

Although some weaker candidates simply wrote down the incorrect answer of 2.5 for part (a), the overwhelming majority of candidates recognized that $2^{-0} = 1$ and many correct answers were seen to this part of the question. Part (b) proved to be more problematic with a significant number of candidates simply writing down a numerical value or an incorrect equation, often equating L to a constant. Values of $c = 2.5$ or $y = 2.5$ was only seen on a minority of scripts. Part (c) caused difficulty to many candidates. Many could set up the equation to earn method but then had difficulty solving their equation. For many of these students, their value of *t* was interpreted as minutes (rather than hours) and the final mark, for conversion to the nearest minute, was invariable lost.

Question 12: finance and percentage error

There were a few incorrect answers (2 being the most popular) but invariably a correct answer of 4 was seen on the majority of scripts. Despite the acceptance of using the Financial App on the graphic display calculator (and awarding marks accordingly) very few candidates went down this route with the overwhelming majority of candidates writing down a compound interest formula. Unfortunately for most, the substitution was often incorrect. Many of the incorrect substitutions were either as a result of misinterpreting *interest rate of 10%* as 0.1 rather than 10 in the formula or misinterpreting *compounded half yearly* as implying that there must be a 6 (rather than 2) in the formula. A correct formula of the form $320000\left(1+\frac{10}{2\times 100}\right)^{2\times 2}$ was, as a consequence, not often seen. Percentage error was done quite well with many candidates correctly using their answer to part (b). The lack of absolute value signs was not penalized for method but a negative answer lost the final mark.

Question 13: quadratic functions and simultaneous equations

Whilst some candidates confused the coordinates of B with the value of c and, as a consequence, wrote down an incorrect answer of 13, many correct answers were seen for part (a). Part (b) proved to be very problematic to the majority of candidates. Whilst a significant number of candidates wrote down one equation correctly from the given data, the second equation proved to be too elusive to many. Indeed, on many scripts the candidate simply wrote down a rearrangement of the first equation or simply used the equation $a(0)^2 + b(0) = 5$. Neither of these equations enabled unique solutions for a and b and so, as a consequence, part (c) was poorly attempted.

Question 14: logic

This question proved to be difficult for the vast majority of candidates with many scoring few or no marks at all. Most candidates failed to write parts (a) and (b) as an implication. They mistakenly interpreted the phrase *always has* to mean *if and only if.* In part (c), very few candidates were able to identify a suitable shape (which was not a rectangle) but which had diagonals equal in length. Some identified a square but, of course, this is also a rectangle. Such an answer earned a maximum of one mark. For many candidates, the final mark was the only score achieved on this question as it required a textbook answer.

Question 15: calculus, turning points

Despite the demand to ask (incorrectly) for the local maximum in part (b), many candidates ignored this error and correctly arrived at the required answers to parts (b) and (c). No candidates were penalized as a consequence of this error in the question. Benefit of the doubt was given in the marking of parts (b) and (c) with crossed out work being accepted, and the markscheme for part (c) was set up to facilitate marks for all candidates who had at least attempted part (b). Many correct answers were seen in part (a) but marks were lost in part (b) as many candidates simply substituted $x = 2$ into the original equation rather than into the derivative found in part (a).

Recommendations and guidance for the teaching of future candidates

- Show, where possible, the formula, the substitution, the unrounded answer and the rounded answer.
- Critically examine their answers to see whether or not they are sensible in the context of the problem set.
- Not cross out their work unless it is to be replaced – crossed out working earns no marks at all.
- Practise past paper questions so that they become familiar with the terminology and the type of questions likely to be set.
- Practise more questions where a mathematical justification is required.
- Ensure that they are fully conversant with the formulae which appear in the formula booklet and where exactly these formulae are to be found in the booklet prior to the examination.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 33	34 - 42	43 - 51	52 - 59	60 - 68	69 - 90

General comments

This being the first occasion on which the new syllabus was examined, the intention was that the new additions and approaches to the syllabus feature quite highly, in order to set a level of expectation for teachers preparing students for subsequent examinations. This new content appeared in questions 5 and 6 and the final part of question 4; it is a little disappointing, therefore, to note that the candidates' performance on these questions was not of standard that was hoped for and their performance on these questions has contributed to the drop in the percentage of the candidature that attained a grade 7.

Many of the candidates attempted all the questions, however, the number of trivial attempts at questions 5 and 6 was high. Question 4 saw many unjustified assumptions made in the latter stages and there was a number of candidates who had no idea what an angle of elevation was. The vast majority of the candidates who had been properly prepared for the course made successful attempts at questions 1 to 3 and it was the intention that these questions were accessible to all. Those centres that prepared their candidates for the Normal distribution saw a good return in question 5; although, clearly, there were many that had not. Only the best candidates gained meaningful success on question 6.

The wide range of marks indicated that the better candidates were able to display their knowledge and skills over the entire paper. The examination was deemed to be an appropriate test of the syllabus by the majority of teachers submitting G2 forms and the clarity of wording seems to have been acceptable to the majority.

A number of candidates lost marks in the "show" questions. When candidates are required to reach a given answer that is written to a specified accuracy, they must first write down the value they obtain correct to a higher degree of accuracy and then write down the given value so that these can be seen to be the same. It is worth noting that better progress could have been made in question 6 had candidates used the two *show that* "signposts"; far too many simply gave up.

In the trigonometry question, the use of radians continues to decline; however, the loss of the correlation coefficient due to resetting the TI GDC was again evident.

The areas of the programme and examination which appeared difficult for the candidates

- Using the equation of the regression line to draw it accurately through the mean point of the data.
- Calculating conditional probability.
- Solving an inequality using the GDC.
- Using cosine rule efficiently.
- Being able to interpret 3D diagrams.
- Using the inverse normal function to calculate a value given a probability.
- Mathematical modelling that will increasing become part of the calculus.
- Expressing answers to an appropriate degree of accuracy.

The areas of the programme and examination in which candidates appeared well prepared

- Data was accurately plotted on their graph.
- The use of the AP and GP formulas.

- Placing information on a Venn diagram.
- Units of measurement being shown.
- Sine rule to solve non right-angled triangles.
- The area formula for a triangle.

The strengths and weaknesses of the candidates in the treatment of individual questions

Question 1: scatter diagram and regression analysis

The great majority of candidates found this question to be accessible. The common errors were; incorrect scales or unlabelled axes; confusion between the correlation coefficient and that of determination (the latter is not part of the MSSL syllabus); the regression line not passing through the mean point; the equation of the regression line not being used to estimate a value. There was a small number of centres that did not use the correct, May 2014, IB-provided 2mm graph paper; graphs drawn on squared paper cannot be assessed to the accuracy required and score poorly.

Question 2: sets and probability

This question divided the candidates into two parts: those who knew how to interpret the information in a manner the led to a consistent Venn diagram and those who did not. The use of the word “only” is crucial in this regard.

Follow through to the probability part of the question was contingent on the candidate’s use of the given $n(E) = 22$; information given in the question should be used in subsequent parts. As ever, conditional probability proved a difficult concept for many.

It is recommended that students write probabilities as unsimplified fractions, as doing so increases their chances of gaining follow through marks. A correctly drawn rectangle in the Venn diagram is also awarded a mark.

Question 3: sequences and series

This question saw the greatest success gained by the greatest number of candidates; although the final part did cause difficulties for many. A small minority only approached the question by continuing the pattern and listing numbers; most used the formulas. Of these, a handful of candidates were unable to distinguish between a sequence and a series or between the two types of sequence. Required for success in part (e) was the efficient use of the GDC; an approach using logarithms not applying: it was clear that much of the candidature had no idea where to begin with a question of this nature; further practice with the GDC is recommended.

Question 4: trigonometry; extending to three dimensions

The use of radian measure continues to decline; however there were isolated cases of its use. As mentioned in the G2 forms, the resetting of some makes of the GDC causes this to occur as the default setting (and to remove the correlation coefficient); candidates are expected to know the vagaries of their own calculators.

This question caused far more problems than was envisaged, since its first three parts have been a regular feature of past papers, with only the final part venturing into the new material on the syllabus – the angle of elevation. The sine rule was, by and large, used successfully, as was the correct triangle formula. However, for many, the temptation to resort to Pythagoras’ theorem was too much in part (c). The major misconception was that the median of a triangle also bisects the angle. This caused a significant loss of marks.

Question 5: the normal distribution

There were many excellent responses to this question; there were, however, also many non-responses. This being the first time in some years that the Normal distribution is on the syllabus, it was inevitable that a question testing its knowledge would be set and so these non-responses are disappointing; candidates must be prepared properly for the current syllabus if they are to gain meaningful success.

Of the partial attempts, the majority were able to sketch the curve and evaluate the first probability from its symmetry; thereafter it was obvious that some had not used the GDC to evaluate probabilities – the method being employed being interpolation from the (approximately) 68% and 95% measures on the graph. It is recommended that, as method, a sketch that shows the area to be evaluated is drawn for each part of the question; GDC notation is not acceptable in the examination.

A lot of students found the interpretative part of the question problematic, and many were not able to calculate the mark from a probability in the final part of the question.

Comments were made on the G2 forms that few questions of this nature were made available to teachers prior to the examination; teachers are advised to read around their subject and perhaps looking at the SL Mathematics past papers would be a sound beginning.

Question 6: modelling with the calculus

As expected, this question was very much the discriminator in the examination and caused the most difficulty for the candidates; however, it must be said that there were a number of excellent attempts, in which the candidate understood fully what was being asked and was able to gain complete or meaningful success.

It is expected that situations of this type, where modelling and optimization through the calculus is required, will form an ever more important part of the syllabus; questions of this nature will recur and must be planned for. This question was a challenge for the majority, most especially in the use of π in the formula; however, if cylindrical objects are to be optimized, this cannot be avoided. Candidates must be prepared by their teachers for questions of this nature and need to have experienced a wide variety of situations of this type: constraints can be cost, length, area or volume, for example; as can the quantity to be optimized.

In the question itself there were two *show that* “signposts” that candidates should have used. Such signposting allows further progress for the candidate who keeps their head and will appear in most problems of this sophistication.

The major errors were a confusion between length and area in part (a), a miscounting of the struts between the ends (although the diagram was given) and between the total length (T) of the structure and the length (l) of the struts. G2 forms mentioned the confusing nature of having three variables in the problem; unfortunately, it is not possible for such questions to have fewer than three.

Some candidates used an approximation for π in their differentiation – and this is acceptable. Very few took advantage of the given value of r to complete parts (f) and (g); this was disappointing.

Recommendations and guidance for the teaching of future candidates

- Use SI units and teach proper scaling.
- Time management – a mark a minute is the guide – and ensure that all questions are attempted.
- Cover the entire syllabus; it will all be examined – if not in Paper 2 then in Paper 1.
- Ensure that the current syllabus documentation is used.

- Have the students take care in the accuracy of their calculations and answers, this is a point that requires constant reminder. Premature rounding is likely to be an issue for multi part questions. Students should show and use unrounded intermediate answers as much as possible.
- Show units.
- Read each question carefully; it will avoid the confusion in questions like 6(a).
- Understand the commands such as Find, Show that, Sketch, Draw, and Calculate.
- Students need to be competent in using the advanced features of their GDCs.
- Where relevant, use diagrams and sketches to illustrate the information; such as in questions 4 and 5.
- Start each question on a new page of an IB answer booklet.